

THE EFFECTS OF RESPONSE EFFICIENCY ON FUNCTIONALLY EQUIVALENT COMPETING BEHAVIORS

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Three experiments addressed the role of response efficiency in the application of functional equivalence training. Functional equivalence training includes conducting a functional assessment of the problem behavior. Variables that predict and maintain the problem behavior are defined, and socially appropriate, functionally equivalent skills are identified and taught. The logic is that if the learner has a socially appropriate way to achieve the same function, he or she will be less likely to use problem behaviors. This study examined the role of response efficiency in functional equivalence training. Response efficiency was examined in terms of three variables: (a) physical effort, (b) schedule of reinforcement, and (c) the time delay between presentation of the discriminative stimulus and reinforcer delivery. Each of the three experiments involved a person who performed a set of problem behaviors and a functional assessment of the problem behaviors. A socially appropriate alternative response was taught, but this new response was less efficient than the problem behavior on one of the efficiency variables (effort, schedule, delay in time). The new behaviors did not compete successfully with the problem behaviors until a new, more efficient, alternative behavior was taught. These results are discussed in terms of our understanding of response covariation and the need in applied contexts to include response efficiency in any functional analysis assessment.

DESCRIPTORS: response efficiency, functional equivalence training, competing behavior analysis

Functional equivalence training is an intervention approach long advocated in applied behavior analysis to reduce problem behaviors (Baer, Wolf, & Risley, 1968; Bijou & Baer, 1978). Functional equivalence training involves two major steps. First, a functional assessment is conducted to define the stimuli that predict and maintain a problem be-

havior. Second, training is provided to build a socially appropriate response that will be under control of the same antecedent stimuli and consequences as the problem behavior. The new, socially appropriate response will be a member of the same response class (Johnston & Pennypacker, 1980; Milinson & Leslie, 1979) as the old problem behavior and will replace the problem behavior in the repertoire of the student (Carr, 1988). Most demonstrations of functional equivalence training have taught a manding response, such as requesting assistance or requesting a desired event, to replace an aggressive or self-injurious response. Recently, functional equivalence training has received renewed attention on a theoretical level (Carr, 1988; Durand, 1990; Horner & Billingsley, 1988), in clinical recommendations (Carr, Robinson, & Palumbo, 1990; LaVigna & Donnellan, 1986; Meyer & Evans, 1989; Repp & Singh, 1990; Schreibman, Charlop, & Koegel, 1982), and in experimental analyses of problem behavior (Carr & Durand, 1985; Dunlap,

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Kern-Dunlap, Clarke, & Robbins, 1991; Durand, 1984; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982; Repp, Felce, & Barton, 1988; Wacker et al., 1990). Although cautions have been raised that functional equivalence training should not be perceived as a panacea (Meyer & Evans, 1989; Paisey, Whitney, & Hislop, 1990), the procedure has received increasingly wide documentation (Carr, Robinson, Taylor, & Carlson, 1990).

This paper examined the role of response efficiency in functional equivalence training. We believe at least three variables affect the efficiency of a response: (a) the physical effort required to perform the response (the calories of energy expended), (b) the schedule of reinforcement, and (c) the delay in time between presentation of the discriminative stimulus for a target response and delivery of the reinforcer for that response (Horner, Sprague, O'Brien, & Heathfield, 1990). For example, head hitting and signing "break" may both serve as responses that result in removal of a difficult task. Signing "break" may be more efficient if it requires less effort than head hitting, is followed by a break each time the response is emitted, and the learner gets the break immediately after requesting it. Head hitting may be more efficient, however, if signing "break" must be done several times to get the teacher's attention (or if signing is followed by significant delays), whereas head hitting gets immediate results.

Our basic thesis is that functional equivalence training is effective because a new, more efficient response is added to an existing response class. We believe functional equivalence training works only when the new response is (a) under the same stimulus control as the problem behavior(s), (b) produces the same outcome that maintains the problem behavior(s), and (c) is more efficient than the problem behavior(s). In some clinical situations in which functional equivalence training has been used unsuccessfully, it is possible that the failure was due to the instruction of a new, socially appropriate response that was not as efficient as the existing problem behavior. Horner et al. (1990) reported a study with a 14-year-old student in which a less efficient, socially desirable mand failed to replace a

very efficient problem behavior. When a second highly efficient mand was targeted, however, it competed successfully with the problem behavior. Unfortunately, the Horner et al. (1990) study did not allow separation of different efficiency variables. This report provides three replications of the role response efficiency plays in successful functional equivalence training. In addition, the present study extends the Horner et al. (1990) analysis by presenting multiple subjects with multiple tasks and by providing more detailed analyses of physical effort, schedule of reinforcement, and latency between discriminative stimulus and reinforcer as important elements of response efficiency.

In each of three experiments, a functional assessment and brief functional analysis were conducted to document a consequence maintaining the problem behavior. An alternative manding response was taught, but the alternative response was designed to be less efficient than the problem behavior in terms of physical effort (for Paul), schedule of reinforcement (for Peter), or time delay between discriminative stimulus and reinforcer delivery (for Mary). A second, more efficient, manding alternative was then taught, and the effects of the low-efficient and high-efficient manding alternatives were compared.

GENERAL METHOD

Participants

Three individuals living in a community residential support program participated. Paul was 12 years old and was diagnosed as having cerebral dysgenesis, left spastic hemiparesis, severe hearing loss in his left ear, and severe mental retardation. His Vineland Social Maturity Scale scores indicated an age equivalence of 1 year 10 months. Paul understood simple requests, used 20 manual signs to request objects, and was able to perform simple self-care skills. Paul had a 6-year history of severe aggression toward himself and others. He engaged in severe hitting, kicking, and scratching of others, and severe self-hits to his head. Paul was not receiving any medications during the study, and his individualized habilitation plan focused on devel-

Table 1
Acquisition and Efficiency Training Tasks

Acquisition tasks		Efficiency training tasks
Paul	Put on a pullover t-shirt	Tie shoe Fasten pants Brush teeth
Peter	Match picture of objects to real objects	Open a jar lid Match similar objects Thread belt through belt loops
Mary	Use manual signs to request desired objects, "want soda" Pull covers over her bed Use screwdriver	Follow simple directions such as "put the spoon in the drawer and shut the door" Rinse dishes Make toast

opment of independence in his self-care routines, indicating preferences by signing yes or no, and communicating specific preferences using signs.

Peter was 14 years old and had a formal diagnosis of profound mental retardation with autistic tendencies. Peter had an 11-year history of severe self-injurious behavior (SIB). When presented with difficult tasks, he would engage in face hits. Peter responded to simple verbal requests and was able to complete simple self-help skills with modest staff assistance. Peter's Vineland Social Maturity Scale scores indicated an age equivalence of 1 year 9 months. He was not receiving medication during the study, and his individualized habilitation plan focused on building personal management skills, teaching communication via existing gestures, and reducing problem behaviors.

Mary was 27 years old and was diagnosed with autism and severe mental retardation. Her Vineland Social Maturity Scale scores indicated an age equivalence of 3 years 5 months. She responded well to simple requests and was independent on basic self-care skills. Her expressive language was limited to single words. Mary had been receiving extensive program support during the previous 5 years in response to her severe self-injury (head hitting). Although Mary had received an array of medications since age 13, she was not taking medication during the course of the study. Her individualized habilitation plan focused on communicating her wants via manual signs, performing personal man-

agement skills, and increasing participation in the local community.

Settings

All instruction and data collection were conducted in the group home where the 3 participants lived or in the work setting where Mary was employed. Training occurred in the bedroom for dressing tasks, in the kitchen or family room for cooking, washing, and requesting tasks, and in the bathroom for teeth brushing and hygiene tasks.

Tasks and Materials

Two sets of tasks were used during the study. Acquisition tasks were used during the assessment and efficiency analyses when participants were acquiring new manding skills. Efficiency training tasks were used during the main efficiency assessment phases of the study. The acquisition tasks were selected from each participant's individualized habilitation plan and were based on staff opinion regarding difficulty (e.g., the participant performed correctly no more than 33% of the time). The efficiency training tasks were also selected from the individualized plan and were also considered difficult. The acquisition and efficiency training tasks for each participant are listed in Table 1.

A Sony® AVC-3450 videocamera was used to record segments of acquisition training sessions with each participant. These segments were then used to validate the independent variable manipulations.

Measurement

Four classes of behavior were measured during the course of the study: (a) problem behaviors, (b) manding responses, (c) attempts to perform the acquisition tasks, and (d) independent variable controls. All data were collected during 15- to 20-min training sessions conducted three to five times per week (no more than one session per day). Each training session allowed the opportunity for at least 10 training trials. The major dependent variables were measured in terms of the percentage of training trials in which the targeted response occurred at least once. A training trial commenced with the presentation of the trainer's request to perform the task, and ended with completion of the task or removal from the task (complete trials required between 2 s and 60 s to perform). Data were collected by one or two independent observers who were present during all assessment and training sessions.

Problem behaviors. The problem behavior for Paul was any aggression (hit, bite, scratch to his own head or to the body of the trainer). For Peter, the targeted problem behavior was SIB in the form of any sharp contact between Peter's hands and his head. For Mary, the targeted problem behavior was SIB or any aggression (instance of self-hitting, hitting, biting or scratching the trainer, or hitting the walls and table around her). Within each session, observers monitored any occurrence of problem behavior during a trial.

Manding responses. Paul learned two manding responses: (a) the American Sign Language (ASL) signs for "I want to go, please," and (b) the ASL sign for "break." Peter learned the ASL sign for "help," and Mary learned to hand the trainer a card (7.5 cm by 12.5 cm) with the word "BREAK" on it. As with problem behaviors, manding responses were measured in terms of whether they were performed to criterion at least once during the trial. During one phase, Paul's signing was measured in terms of trials in which the complete sentence was signed (criterion performance) and trials in which any formal sign was used (criterion plus noncriterion performance). During two phases, Pe-

ter needed to sign for help three times before help was provided (fixed-ratio [FR] 3). During these phases, observers recorded the trials per session in which three signs were presented (criterion) and the trials per session in which at least one sign was made (criterion plus noncriterion performance). Similarly, Mary experienced two phases in which she needed to wait 20 s after giving the card to the trainer before she got a break. Observers recorded the trials per session in which she presented the card and waited 20 s (criterion) and the trials per session in which she presented the card at all (criterion plus noncriterion trials). A session generated a score of the percentage of training trials in which a targeted manding response was performed to criterion. A separate percentage was computed for trials in which any use of the manding response occurred.

Attempts to perform the task. Our experience with these participants indicated that if they attempted the initial steps of a trial, they would complete the trial. Most aggression and disruptive behavior occurred at the beginning of a trial. A central concern was whether the participants would continue to attempt to perform the task when they were taught manding responses allowing them to escape from the task. An attempt was defined as any trial in which the participant performed the initial step in the task analysis within 5 s after the trainer presented the trial.

Independent variable controls. The independent variable under analysis was the overall efficiency of the new manding responses relative to the problem behaviors. To confirm the manipulation of the efficiency variables (physical effort, schedule of reinforcement, latency), nine 10-s video segments were recorded for each participant. Three segments recorded the participant performing his or her problem behavior(s), three segments recorded the participant performing his or her low-efficiency alternative response, and three segments recorded the participant performing his or her high-efficiency alternative response. Five professionals in developmental disabilities who were not associated with the study were recruited to review these videotape segments. Each reviewer had a minimum of 3 years

of experience in direct support for people with severe intellectual disabilities.

The reviewers provided a subjective index of the physical effort required to perform the problem behavior, the low-efficiency manding behavior, and the high-efficiency manding alternative. Each reviewer watched the videotapes alone. The order of participants presented and the order of behaviors for each participant were randomized for each reviewer. Reviewers watched a 10-s segment of tape and then recorded the level of physical effort required to perform the observed behavior on a 10-point Likert-type scale. Reviewers received the following instructions:

Your are to rate each video presentation according to the amount of physical effort required to perform the behavior. "Effort" may be affected by the amount of strength required, the number of movements, or the duration of a behavior. Increases in one or all of these features could contribute to greater physical effort. Rate only the behavior specified and ignore any other behaviors. After viewing each segment, rate the amount of physical effort on the scale below.

Results from this process were used to determine the average observed level of effort (mean of the five reviewers) for each of the three types of responses (problem behavior, low-efficiency alternative, high-efficiency alternative) for each participant.

The video segments were also reviewed by project staff, who recorded the schedule of reinforcement for each of the observed behaviors and the latency between the performance of the target response and the delivery of the presumed reinforcer.

Interobserver Agreement

Two independent observers recorded problem behaviors, manding responses, and attempts during at least 25% of the trials for each participant during training sessions. Agreements were computed separately for problem behaviors, manding, and attempts, even though all three could have occurred during any one trial. An agreement for problem

behavior was recorded if both observers recorded the trial as having included the problem behavior. If only one of the observers recorded the trial as having included the problem behavior, a disagreement was recorded, and if both observers recorded the trial as not including a problem behavior, the trial was ignored. Percentage agreement was calculated by dividing the number of agreements per session by the number of agreements plus disagreements and multiplying by 100%. The same process was used to develop agreement scores for manding responses and attempts.

Interobserver agreements averaged 95% or above for each participant on problem behaviors, manding responses, and attempts across all phases for each participant.

STUDY 1: EVALUATION OF PHYSICAL EFFORT

Assessment and Design

A preliminary interview with Paul's training and group-home staff was conducted to define potential predictive and maintaining events (cf. O'Neill, Horner, Albin, Storey, & Sprague, 1991). From this interview, the hypothesis was proposed that Paul's aggression was maintained by escape from difficult tasks. An ABAB functional analysis was conducted to test this hypothesis. The two assessment phases were (a) break after aggression or each trial and (b) break after aggression or every 15 trials. Following the assessment phases, four efficiency analysis phases were conducted to examine the efficiency of two functionally equivalent alternative behaviors. The four efficiency analysis phases were (a) sentence sign training, (b) sentence sign, (c) word sign training, and (d) word sign.

Procedures

Break after aggression or each trial. During this phase, Paul was presented with a t-shirt in his bedroom and given the instruction, "Put your shirt on." If he initiated the task, he was given trainer assistance following guidelines defined by Bellamy, Horner, and Inman (1979). Errors were followed by stopping the task, returning to the step where

the error occurred, and repeating the step with additional assistance. After each trial, Paul received verbal praise and a 30- to 45-s break during which he walked to his window and looked outside. If Paul aggressed against himself or the trainer at any point during a trial, the trainer interrupted or blocked the aggression, the trial was stopped, and Paul was told to take a 30- to 45-s break.

Break after aggression or 15 trials. The same task and training procedures were employed, except the completion of one trial was followed by verbal praise, removal of his shirt, and the presentation of a new trial (with a different shirt). After 15 trials, the session ended and Paul was told to take a 30- to 45-s break. If he aggressed at any point during any trial, the trial was terminated, and he was asked to take a 30- to 45-s break.

Sentence sign training. Paul received six sessions of training to learn how to sign "I want to go, please." Training followed the same schedule and length as the acquisition task, except during this phase, Paul received training on three efficiency training tasks. If Paul signed "I want to go, please," he received a 30- to 45-s break. He was prompted by the trainer to use the signed sentence during each trial of a session. The tasks being trained were rotated after each one to two trials within a session. All training procedures, correction procedures, and responses to aggression were the same as in previous phases. Sentence training was terminated when Paul correctly and independently used the signed sentence during at least 10 trials on each of 2 consecutive days.

Sentence sign. During the seven sessions of the sentence sign phase, Paul received training on the acquisition task (putting on a t-shirt). All training, correction, and responses to aggression were the same as in previous phases. The only difference was that Paul could obtain a break by signing "I want to go, please," or by aggression. A session ended after 15 trials or 15 to 20 min.

Word sign training. Paul received training on signing the word "break" during three sessions. The procedures for training the word "break" were identical to the procedures used during the sentence sign training phase. The criterion for terminating

word sign training was the same as that used for sentence sign training.

Word sign. Procedures during the 16 days of this phase replicated those of previous phases, except a 30- to 45-s break was delivered after aggression, after signing "I want to go, please," or after signing "break."

Results

Assessment. Results from Study 1 are presented in Figure 1. The first four phases provide an evaluation of the hypothesis that aggression was maintained by escape from training. Across the two break after aggression or each trial phases, Paul aggressed during an average of 12.5% of the trials. Across the two break after aggression or 15-trials phases, Paul aggressed during an average of 82.5% of the trials. The immediacy of the level changes, the absence of overlap across adjacent phases, and the intraphase stability provide strong documentation of a functional relationship between the 15-trial procedure and increased aggression. This supports the hypothesis that aggression was maintained by escape from difficult tasks.

Results for trials attempted indicate that during the two break after aggression or each trial phases, Paul attempted to perform the task on 93.2% of the trials. Across the two 15-trial phases, Paul's attempts dropped to 29.5%.

Efficiency. During the last 15-trial phase, Paul aggressed during an average of 91% of the training trials. He attempted to complete an average of only 15% of the trials during this phase. After training to sign "I want to go, please," Paul's behavior showed an initial change that deteriorated across the seven sessions of the sentence sign phase. During the first two sessions after training (Sessions 21 and 22), Paul signed "I want to go, please," during 55% and 78% of the trials, respectively, and made attempts during nearly 50% of the trials. His level of aggression dropped to 30% to 35%. These initial gains were short-lived, however. By Session 23, Paul was very unlikely to sign that he wanted a break. Across the next four sessions (24 to 27), there was a dramatic increase in the level of aggression and a decrease in the level of attempts per

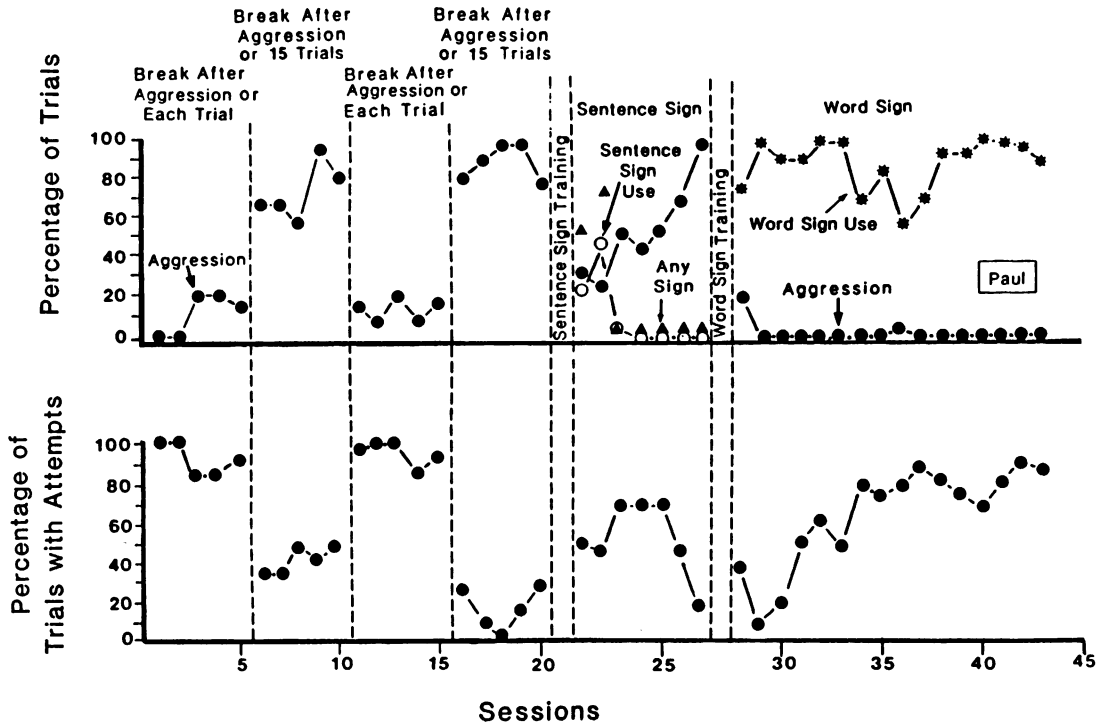


Figure 1. The percentage of trials per session with aggression for Paul across assessment phases. The upper panel indicates the percentage of trials per session in which Paul aggressed or used signing. The lower panel indicates the percentage of trials in which Paul attempted to perform the task.

session. The sentence sign phase ended with approximately the same level of aggression and attempts as in the previous 15-trial phase.

After learning to sign "break," Paul's behavior demonstrated immediate and sustained changes. Aggression during the 16 days of this phase averaged only 1.9%, whereas manding occurred during an average of 88% of the trials. During the initial sessions of this phase (28 to 30), Paul used "break" to escape from the task without initiating an attempt to put on his shirt. As the phase progressed, however, he would put on his shirt and then sign "break." As can be seen in the attempts data of Figure 1, there was a gradual increase in the proportion of trials in which Paul attempted across the phase. Even though he had the ability to escape every trial, he ended the phase attempting an average of 80% of the trials during a session. At no time during the word sign phase did Paul sign "I want to go, please."

Independent variable. Reviewers examining video segments of Paul performing aggression, sentencing signing, and word signing rated the three responses as averaging 2.1, 5.6, and 1.2 in physical effort, respectively. All three responses were on a continuous reinforcement schedule, and each response was reinforced with access to a break within a latency of 1 s after performing the response.

STUDY 2: SCHEDULE OF REINFORCEMENT

Assessment and Design

Assessment procedures for Peter replicated those for Paul. Staff indicated that Peter's self-injurious behavior was maintained by obtaining trainer assistance when he performed difficult tasks. Trainer assistance took the form of additional trainer prompts (verbal and gestural) when a trial was presented. To test this hypothesis, an ABAB anal-

ysis was conducted with phases in which trainer assistance was delivered immediately upon presentation of the trial and in which trainer assistance was delivered only after an instance of self-hitting. After the assessment, Peter was taught the ASL sign "help," and a series of phases was conducted in which "help" was followed by assistance after each instance of signing (FR 1) or after Peter signed "help" three times (FR 3).

Procedure

Immediate assistance. Peter received discrete-trial training on matching pictures of grocery items to real grocery items on a table. Three items were presented along with the picture for one of the items, and he was asked to place the picture in front of the correct item. The pictures were color photographs (15 cm by 10 cm). A trial began when Peter was presented with the picture and ended when he made a selection or performed a SIB response. As soon as the picture was presented, the trainer delivered additional prompts, such as pointing to the picture and pointing to or saying the correct item. Trainers provided the minimal assistance needed to obtain correct responding. Accurate trials were followed by verbal praise. Errors were followed by stopping the trial, backing up to the picture, and providing additional assistance as recommended by Bellamy et al. (1979). If Peter slapped himself in the face, the response was interrupted, and trainer assistance continued to be delivered.

Assistance after SIB. This phase replicated the immediate assistance phase except the trainer delivered additional training prompts only after face slaps. A trial began by presenting the materials and the picture. Errors were corrected, but additional assistance was not provided.

Sign training. During the sign training phase, Peter was trained to use the ASL sign for "help." He was presented with the three efficiency training tasks and was taught to obtain trainer assistance by signing "help." Errors and SIB were interrupted, and the trainer prompted use of the "help" sign. Trainer assistance was delivered each time Peter

signed for help or provided an approximation of the appropriate sign. This phase ended when Peter signed "help" during 10 trials on each training task across two consecutive sessions. The sign training phase was implemented on three different occasions; the first sign training phase lasted 21 sessions, and the second and third phases each lasted two sessions.

FR 3. During this phase, Peter received teacher assistance on the picture-matching task any time he engaged in SIB or if he signed "help" three times during the trial. All other training procedures replicated those used during the assessment phases.

FR 1. This phase replicated the FR 3 phase, except that trainer assistance was delivered after a single "help" sign.

Results

Assessment. The results of Study 2 are provided in Figure 2. Peter engaged in self-injurious responses during only 4% of the trials across the two immediate assistance phases. He engaged in self-injury during 87% of the trials presented during the nine sessions conducted over the two assistance after SIB phases. The immediate ABAB reversal pattern across the four phases supports the hypothesis that access to trainer assistance was a reinforcer maintaining self-injurious behavior. Peter's results on attempting the task across the four assessment phases was at a uniform 100% for all sessions in each phase.

Efficiency. During the last assistance after SIB phase, Peter attempted to perform the task on every trial, but he also engaged in SIB during nearly every trial. After he was taught to request trainer assistance by signing "help," he entered an FR 3 phase in which he obtained trainer assistance by signing "help" three times. His results indicate an initial reduction in his level of self-injury to only 10% to 30% of the trials within a session. He continued to attempt on nearly every trial, and he used the new mand on 80% of the trials. Across the seven sessions in this phase, however, Peter's initial gains declined greatly. His use of signing gradually decreased to near zero. His level of self-injurious behavior returned to 95% to 100% of the

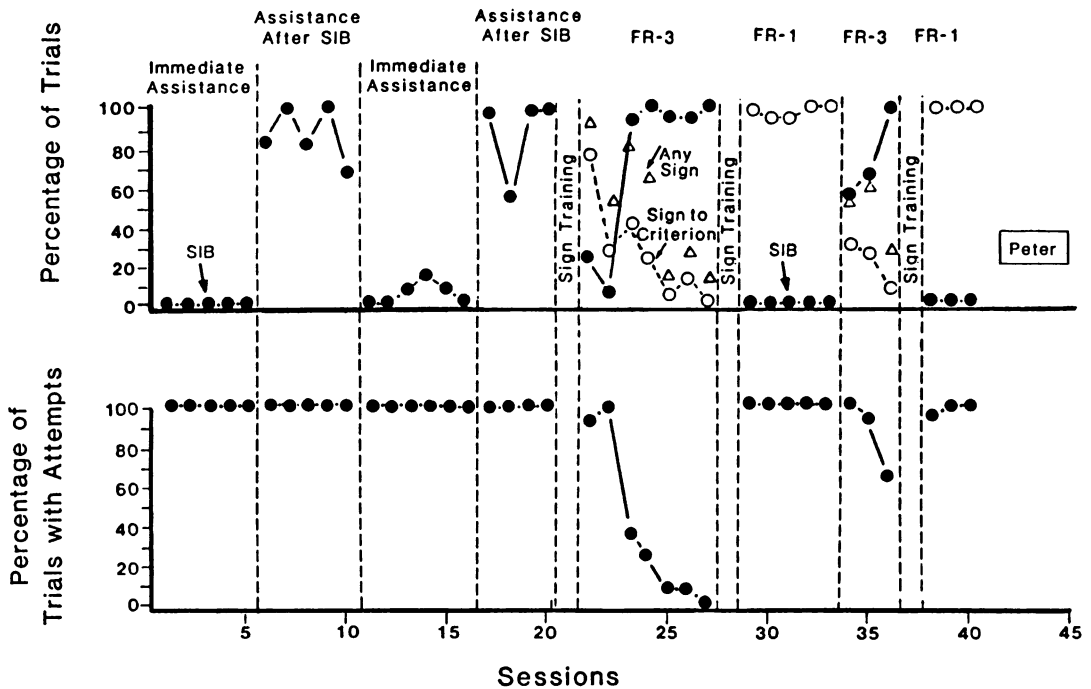


Figure 2. The percentage of trials per session with SIB for Peter. The upper panel indicates the percentage of trials per session in which Peter engaged in SIB or signing. The lower panel indicates the percentage of trials in which Peter attempted to perform the task.

trials, and he stopped trying to perform the task before he would slap himself.

After additional training to reestablish the "help" response, Peter entered the first FR 1 phase. In this phase, he signed for help on nearly every trial, attempted every trial in every phase, and engaged in no self-injurious behavior. Return to the FR 3 conditions resulted in a dramatic reduction in the use of the "help" sign, an immediate increase in the level of self-injury, and a drop in Peter's attempts to complete the task. When FR 1 conditions were reestablished during the last five sessions, Peter's self-injurious behavior dropped to near zero, his use of the "help" sign occurred on every trial in every session, and his attempts to complete the task returned to a near 100% level.

Independent variable. The five reviewers found minimal difference in the physical effort required to self-slap, sign "help," or sign "help" three times. They rated the three responses an average of 1.5, 1.3, and 2.3, respectively, on the 10-point Likert-

type scale. The schedule of access to teacher assistance (FR 1 vs. FR 3) was exactly as predicted by the procedures, and the latency between target behaviors and access to teacher assistance was 1 s.

STUDY 3: DELAY

Assessment and Design

An interview with Mary's residential staff led to the hypothesis that Mary's aggression was reinforced by escape from difficult tasks. An initial ABAB assessment was conducted using procedures similar to those implemented for Paul. After the ABAB assessment, Mary was taught to hand the trainer a card with the word "BREAK" on it. A series of reversals was conducted to determine if the delay between handing the card and receiving the break (1-s delay vs. 20-s delay) affected the extent to which this new manding response competed successfully with aggression.

Procedure

Break after one trial or aggression. Mary received training on three different acquisition tasks: (a) using ASL signs to identify items (e.g., soda) that she was thought to prefer, (b) pulling the covers over her bed (making bed), and (c) using a standard screwdriver to tighten screws. The tasks were rotated across sessions to ensure that they would remain difficult throughout the study. The same prompting, correcting, and praising procedures used with Paul and Peter were replicated with Mary. During this phase, Mary was told, "Take a break," and would receive a 30- to 40-s break to wander around the room after each trial or after an aggression (against herself or the trainer). If Mary attempted to take a break without completing a trial or aggressing, she was verbally prompted to continue the trial.

Break after 20 trials or aggression. This phase replicated the previous phase, except that Mary received a break after completing 20 trials or after an aggression.

Card use training. Mary worked on her three efficiency training tasks and was taught to hand an index card (7.5 cm by 12.5 cm) to the trainer. When she handed the card to the trainer, she was told to take a break. All training procedures replicated the other phases, and Mary continued to get a break if she aggressed. Card use training was terminated when Mary used the card during 10 trials across two consecutive sessions. Card use training was conducted on three different occasions; the first phase involved a total of nine training sessions, and the second and third phases required three and two sessions, respectively.

20-s delay. The 20-s delay phase involved teaching the original acquisition tasks while replicating the training procedures from earlier phases. The only change was in the contingencies associated with obtaining a break. During this phase, Mary was given a break any time she aggressed or 20 s after she handed the break card to the trainer. When Mary handed the card to the trainer, the trainer would take the card, avoid eye contact with Mary, count to 20, and then say, "OK Mary, take a break."

1-s delay. The 1-s delay phase replicated the 20-s delay phase except the trainer only counted to 1 before telling Mary she could take a break.

Results

Assessment. Figure 3 presents the assessment results from Study 3. The results indicate that aggression occurred on an average of 6% of the trials when breaks occurred after every trial and on 63% of the trials when breaks occurred after 20 trials. The data follow a clear ABAB reversal pattern with immediate and substantial level changes, uncomplicated by significant trends. These results support the hypothesis that Mary's aggression was maintained by escape from the acquisition tasks. Mary attempted the task on 99.5% of trials during the one trial or aggression phases, whereas during the 20-trials phases, she made attempts on an average of 86.5% of trials.

Efficiency. After aggressing during 60% of the trials in the last 20-trials phase, Mary was taught to hand the break card to the trainer. During Sessions 22 and 23 of the first 20-s delay phase, Mary handed the card to the trainer on 70% and 40% of the training trials. She handed the card and waited for her break on 5% and 10% of the trials. She rapidly learned that she could get a break much faster by aggressing than by handing the card and waiting. There was no decrease in aggression during this phase. In fact, the level of aggression rose from 60% in the preceding phase to an average of 94% across the five sessions in the first 20-s delay phase.

After retraining in card use, Mary entered the 1-s delay phase. During this phase Mary used the card during 92% of the trials, and her level of aggression dropped to an average of 17% (with a strong decreasing trend). When the 20-s delay procedures were reinstated, Mary immediately reverted to using aggression and stopped using her break card. After retraining on card use and reinstitution of the 1-s delay criterion, Mary returned to a pattern of strong card use with minimal levels of aggression.

Mary's attempts to complete the task across the efficiency analysis ranged between 50% and 100%, with no clear pattern associated with the indepen-

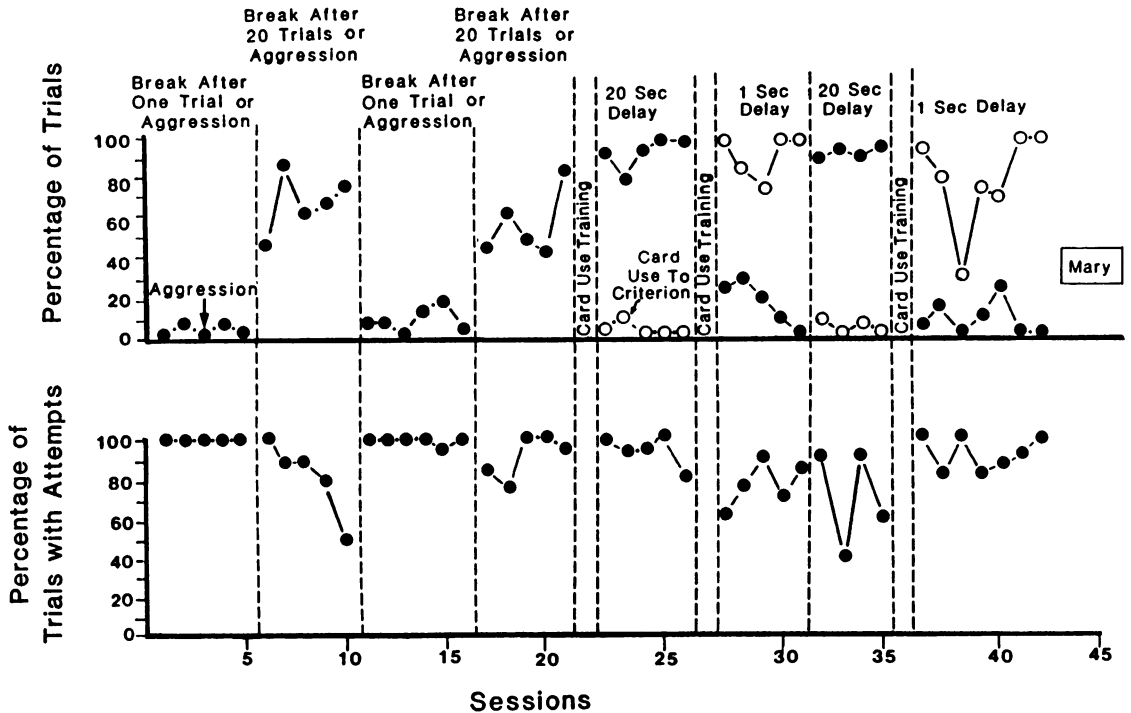


Figure 3. The percentage of trials per session with aggression for Mary. The upper panel indicates the percentage of trials with aggression or card use across phases. The lower panel indicates the percentage of trials in which Mary attempted to perform the task.

dent variable manipulations. She generally attempted to do the tasks she was given.

Independent variable. The five reviewers examined video segments of Mary's aggression, card use during the 20-s delay, and card use during the 1-s delay. Their average rating for the physical effort of the three responses was 2.5, 1.3, and 1.3, respectively. The schedule of reinforcement was FR 1 for all three responses, and the delay between the target response and the delivery of the reinforcer was 2 s for aggression, 20 s for the 20-s delay phase, and 1 s for the 1-s delay phase.

GENERAL DISCUSSION

We have long been aware that behavior is affected by variables such as physical effort (Chung, 1965; Schroeder, 1972), schedules of reinforcement (Ferster & Skinner, 1957; Herrnstein, 1961), and delays (Mace et al., 1988; Millenson & Leslie, 1979). The purpose of the present study was to

analyze the role of these variables in response allocation among members of a response class, that is, how they affect the competition between two or more behaviors that produce the same functional effect (Herrnstein, 1970; Herrnstein & Loveland, 1975).

The results provided three demonstrations of functional equivalence training in which new, socially appropriate, alternative behaviors did not result in decreases in targeted problem behaviors. In each case, data supported the hypothesis that the reason the new, functionally equivalent behaviors did not affect levels of problem behavior was due to the comparative response efficiency between the problem behavior and the new behavior. When an efficient alternative behavior was taught, there were dramatic reductions in the problem behaviors.

A theoretical implication of the results lies in the way negative behaviors are assigned to response classes. We should avoid viewing problem behaviors and socially desirable behaviors as members of

different response classes. Response classes are defined by their effect, not by their topography (Haynes & O'Brien, 1990; Johnston & Pennypacker, 1980). As we examine the covariation between desirable and undesirable responses (Haring & Kennedy, 1990; Mace & Belfiore, 1990; O'Neill, Horner, O'Brien, & Huckstep, 1991; Parrish, Cataldo, Kolko, Neef, & Egel, 1986; Russo, Cataldo, & Cushing, 1981; Sprague & Horner, in press), we predict that the development of new skills will affect other behaviors in the same response class but will have less direct impact on responses in different response classes. Analysis of covariation should begin by defining the variables maintaining targeted responses to determine whether they are members of a single or multiple response class. Further analysis is needed of the variables contributing to the competition among behaviors both within response classes and across response classes.

Careful interpretation of the present results also requires consideration of potential confounding effects and alternative explanations for the observed patterns. A major assumption in the three studies was that the magnitude of reinforcement was held constant for the problem behavior, inefficient mand, and efficient mand. This was done by (a) documenting that access to breaks or teacher assistance was a controlling reinforcer and (b) artificially ensuring that this reinforcer was delivered at the same intensity after all three responses. It is possible, however, that variations in the manner in which assistance was provided, or in the tone of voice of the trainer when allowing a break, may have made the comparative levels of reinforcement unequal. Although every effort was made to control for consistency in teacher praise, posture, and tone of voice, it is impossible to ensure that the reinforcers delivered across trials were equal.

Another issue affecting interpretation of the results is recognition that by reinforcing every occurrence of problem behaviors, we most likely increased the efficiency of the problem behaviors over natural levels. It is possible that if SIB and aggression had been ignored or blocked, the less efficient manding alternative would have competed successfully. We artificially improved the schedule

of reinforcement for the problem behaviors to maximize our ability to hold magnitude of reinforcement constant while focusing on response efficiency variables.

A final consideration affecting interpretation of the results is acknowledgment that all three studies assessed problem behaviors maintained, at least in part, by escape from difficult or undesirable situations. We have not documented the role of efficiency in situations in which problem behaviors are maintained by automatic reinforcement by access to social and tangible reinforcers. We believe the relationships defined above will hold under alternative response functions, but documentation of that assumption is left to future research.

The results from this study support the growing body of literature documenting the value of functional equivalence training (Carr, 1988; Carr, Robinson, Taylor, & Carlson, 1990). In addition, however, the results support elegant work by Wacker (Wacker et al., 1990; Wacker, Wiggins, Fowler, & Berg, 1988), Carr (Carr, 1988; Carr & Durand, 1985), Durand (Durand, 1990; Durand & Carr, 1987; Durand, Crimmins, Caulfield, & Taylor, 1989), and Mace (Mace, McCurdy, & Quigley, 1990) emphasizing the central role of response efficiency in functional equivalence training. Additional work is needed to define efficiency and the role of efficiency in applied settings. The present results support the importance of response effort, schedule of reinforcement, and delay of reinforcement as important elements of a definition of efficiency. The results also support the need to examine response efficiency as a part of any functional assessment. When functional equivalence is to be used, the results suggest that both the efficiency of the problem behavior and the efficiency of the functionally equivalent alternative behavior be carefully assessed.

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